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journal or publication title	CYRIC annual report
volume	2007
page range	94-96
year	2007
URL	http://hdl.handle.net/10097/44396

VIII. 4. FFA and Glucose Uptake of Skeletal Muscle and Myocardium at Different Exercise Intensity

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Introduction

Efficiency of energy substrate supply from blood is one of the main factors of exercise performance. We previously reported the relationship between glucose uptake of skeletal muscle and myocardium, and exercise intensity^{1,2)}. Glucose uptake of skeletal muscle and myocardium didn't increase according to increment of exercise intensity in untrained men. The purpose of this study was to investigate the relationship between exercise intensity and FFA and glucose uptake of skeletal muscle and myocardium with single photon emission tomography (SPECT) and Positron Emission tomography (PET), respectively.

Methods

Measurement of glucose uptake.

Four-teen healthy subjects (30.4±6.2 years, mean±S.E.) participated this glucose study. Maximal aerobic power ($\dot{V}O_{2max}$) was 49.6±9.7 ml/Kg/min. Each subject was studied on three separate days with time interval of more than two days. Bicycle ergometer at three different workloads was used, 30, 55 and 75 % $\dot{V}O_{2max}$. ¹⁸F-FDG was injected 10 minutes after the beginning of exercise and total exercise time was 35 minutes. PET imaging started immediately after the exercise. PET studies were performed using an eight ring ECAT 931/08 –tomograph. Plasma radioactivity, glucose and lactate acid values were obtained during studies. Quantification of glucose uptake was based on the method developed by Sokoloff et al³⁾. Glucose uptake was measured in the quadriceps

femoris muscle (QF) and in the myocardium.

Measurement of FFA uptake.

Six untrained subjects (20.2 ± 1.2 years) participated FFA study. $\dot{V}O_{2\max}$ was 52.5 ± 2.1 ml/Kg/min. Study design was almost same as the glucose study. ^{123}I -labeled 15-(p-iodophenyl)-3-(R,S)-methyl-pentadecanoic acid (^{123}I -BMIPP) that is tracer of FFA was injected intravenously 5 minutes after the subjects started exercise. Single photon emission tomography (SPECT) measurements were started immediately after the exercise. Tomographic images were obtained from regions of the QF and myocardium. ^{123}I -BMIPP counts per minute indicate the extent of ^{123}I -BMIPP uptake in tissue and were corrected in terms of total whole body count (FU; regional mean count / whole body count; optional unit) in each experiment.

Results

QF glucose uptake increased significantly from 30% $\dot{V}O_{2\max}$ to 55% $\dot{V}O_{2\max}$ intensity ($P < 0.05$), but not further during 75% $\dot{V}O_{2\max}$ intensity (Fig. 1A). QF ^{123}I -BMIPP uptakes at 40% and 55% $\dot{V}O_{2\max}$ intensity were significantly higher than that of 75% $\dot{V}O_{2\max}$ (Fig. 1B). Myocardial glucose uptake did not increase in a linear manner with increasing exercise intensity. At the highest exercise intensity glucose uptake decreased significantly as compared to both 30 and 55% intensity levels ($p < 0.05$) (Fig. 1C). There were no differences in ^{123}I -BMIPP uptake at each experiment in the myocardium (Fig. 1D). Plasma lactate concentration was strikingly increased according to the exercise intensity.

Discussion/Conclusion

These results suggested that blood glucose and FFA were not the main energy source of skeletal muscle and myocardium to increase the exercise intensity in untrained subjects. At higher exercise intensity, intramuscular substrates, most likely glycogen would be the main energy source of the increment of exercise intensity. The increased myocardial energy that is needed during high intensity exercise is supplied by substrates other than glucose, like as lactate.

References

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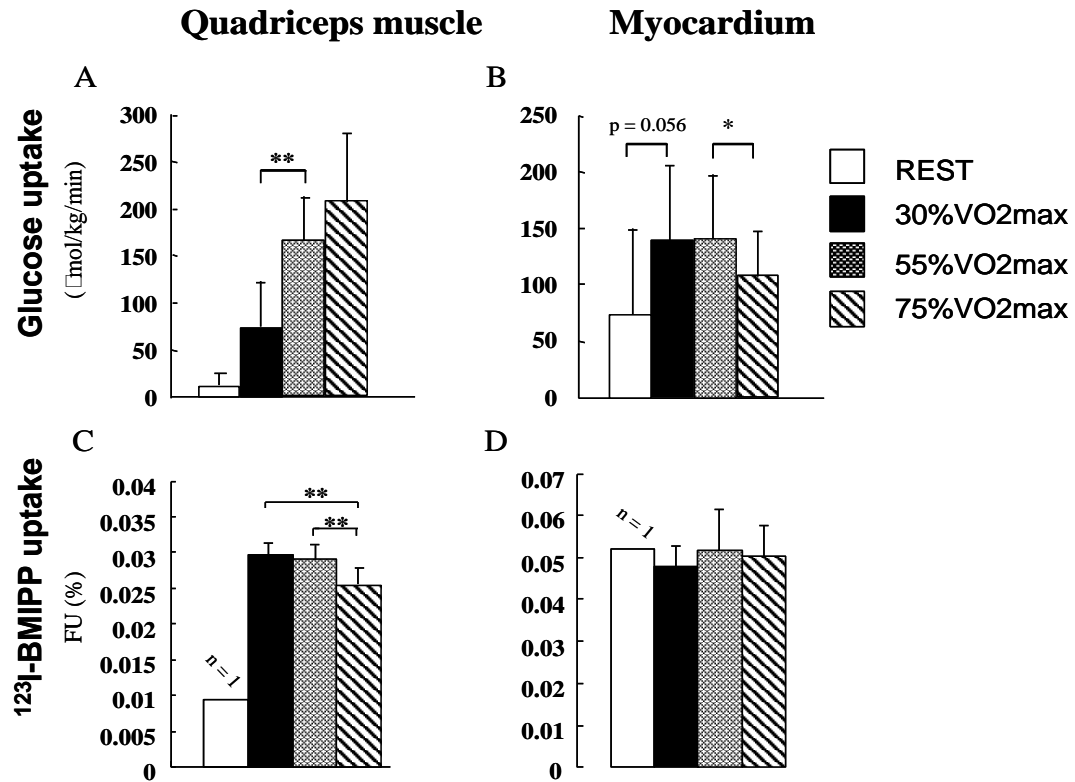


Figure 1. A shows the relationship between the glucose uptake of the quadriceps femoris and the exercise intensity. Figure 1B shows the relationship between the glucose uptake of myocardium and the exercise intensity. Figure 1C shows the relationship between the ^{123}I - BMIPP uptake of the quadriceps femoris and the exercise intensity. Figure 1D shows ^{123}I - BMIPP uptake in the myocardium and the exercise intensity.